UTILIZATION OF WASTE

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FACING TILES BASED ON FELDSPAR MATERIAL AND CAMBRIAN CLAY FROM CHEKALOVSKOE DEPOSIT

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The possibility of using feldspar material from the Chupinskii mining and concentration works in mixtures for the production of ceramic facing tiles is considered. The effect of this material on shrinkage, water absorption, and strength of articles based on Cambrian clays from the Chekalovskoe deposit is studied, and their properties are compared with samples of the mixture used at the Nikol'skii Ceramic Works. The use of quartz-feldspar dust-removal waste makes it possible to exclude lime from the mixture composition and to decrease the quantity of quartz sand requiring milling.

To identify the possibility of using the feldspar material produced by the Chupinskii mining and concentration works in mixtures for ceramic facing tiles, we have investigated the effect of this material on shrinkage, water absorption, and strength of products based on Cambrian clay from the Chekalovskoe deposit and compared their properties with those of samples made from the ceramic mixture used at the Nikol'skii Ceramic Works.

The experimental mixtures were investigated according to the generally accepted method. The preparation of batch included drying, grinding, screening, weighing, and mixing of components in a laboratory ball mill to a residue of 1.5% on a No. 0063 sieve. After 24 h aging the working moisture of the mixtures was equal to 18 – 20%. These mixtures were used to mold tiles of size 50 × 50 × 8 mm.

The tiles were subjected to preliminary drying at a temperature of 105°C and then fired in a KO-14 laboratory Silit furnace at a temperature of 900 – 1100°C with an interval of 50°C. The average rate of temperature rise was 2 – 3 K/min, and the exposure of samples in the furnace after reaching the required temperature was 40 min. The samples were cooled together with the furnace.

The mineral composition of clay was identified using x-ray phase analysis. This analysis was performed on a DRON-3M diffractometer (copper radiation, nickel filter).

The physicomechanical properties of tiles were determined according to GOST 6141–91 prescribing the water absorption of tiles to be no more than 16% and the average bending strength not less than 12 MPa.

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Cambrian clay typically has the pelite or aleurite-pelite structure and stratified or massif texture.

According to its mineral composition, it belongs to polymineral, mainly hydromica clays and by its granulometric composition it is classified as medium-dispersion clay with a low content of coarse-grain inclusions (over 0.5 mm). The granulometric compositions of clay is as follows: content of 1 – 0.25 mm fraction — 0.12 – 0.19% (here and elsewhere wt.%), 0.25 – 0.05 mm fraction — 0.17 – 2.80%, 0.05 – 0.01 mm — 3.09 – 16.03%, 0.01 – 0.005 mm — 26.5 – 47.9%, below 0.001 mm — 45.75 – 59.94% (the fraction of 0.005 – 0.001 mm does nor exist). The content of argillaceous fractions below 0.005 mm is equal to 45.75 – 59.94%.

The chemical composition of clays is homogeneous. The content of the main oxides ranges within the following limits (%): 59.0 – 62.1 SiO_2, 16.9 – 19.0 Al_2O_3, 2.5 – 4.2 Fe_2O_3. The plasticity of the clay according to Atterberg is 13.6 – 15.9, and the melting temperature is 1150 – 1200°C.

Using x-ray phase analysis it was found that the main minerals in argillaceous materials are quartz, feldspars (microcline), chlorite, and minerals of the hydromica group, probably glauconite. The content of free quartz is high, which is corroborated by the perceptible intensity of quartz peaks in the diffraction pattern and by optical microscope data.

Processing (milling and concentration by magnetic separation) of pegmatite for the purpose of producing pegmatite concentrate (with grain size 1 mm) produces dust removal waste (fraction below 0.063 mm).

The optical microscope data indicate that the dust removal waste consists of angular quartz and feldspar grains of

TABLE 1

Material	Weight content, %									
	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	H_2O	calcination loss
Cambrian clay	62.70	0.85	15.45	6.21	2.50	0.97	0.21	5.19	1.11	4.46
Dust recovery waste	70.00	0.06	15.58	1.05	0.41	1.30	3.16	7.63	0.13	0.44
Prosyanovskoe kaolin	47.20	0.61	36.49	0.94	0.10	0.88	0.10	0.92	–	12.60
Quartz sand	98.20	0.04	0.73	0.15	–	–	0.12	0.06	0.06	0.22

size 0.015 – 0.030 mm, less frequently up to 0.200 mm. Part of the grains are tinted gray-brown by iron oxides. Besides, there are grains of ore mineral (below 5%) and single mica grains. The dust removal waste differs from the pegmatite concentrate by its increased content of iron oxides (up to 1%), magnesium (twice as much), alkali oxides (up to 11%), and a lower content of aluminum oxide. These differences in the oxide content in combination with the finer fraction ought to facilitate the sintering of ceramics.

Ceramic mixtures for facing tiles were tested at the laboratory of the Institute of Geology. The product of pegmatite dust removal acts as a flux, i.e., the glass-forming component ensuring the sintering of the mixture and, furthermore, acting as a grog. The plastifying components were Cambrian clay from the Chekalovskoe deposit used at the Nikol'skii Works to produce facing tiles and kaolin from the Prosyanovskoe deposit. The chemical composition of the raw materials is listed in Table 1 and the compositions of facing tile mixtures in Table 2.

The mixture produced at the Nikol'skii Works (Table 2, mixture 5) was taken as the reference composition to test the compositions used at this factory. This mixture has a high content of plastifying components (clay, kaolin) and quartz sand and contains lime as well.

Figure 1 shows the variations in shrinkage, water absorption, and bending strength of the samples depending on their firing temperature.

To study the effect of the feldspar material on the physicomechanical properties of tiles, its quantity in mixtures was varied from 20 to 40% and the properties of these tiles were compared with those made of mixture 5 that does not contain this additive.

The total shrinkage in all mixtures grows uniformly depending on increasing firing temperature. Mixture 1 has low shrinkage values compares to other mixtures, presumably due to the highest content of quartz sand. An increased content of clay with a simultaneous decrease in the content of quartz sand (mixtures 2, 3) or its absence (mixture 4) increases shrinkage. In this case the values of shrinkage at the final firing temperature (mixtures 2 – 4) differ little and are close to the shrinkage of the factory mixture (mixture 5).

The water absorption of mixtures 3 – 5 decreases significantly at a temperature of 1050°C, which indicates the beginning of active sintering. The sintering process in mixtures 2 and 4 has a smooth course up to 1100°C. At the final firing temperature (1100°C) the lowest water absorption is seen in mixtures 2 and 3 (6.05 and 7.46%), close to industrial mixture 5 (6.63%). Mixture 4 has a somewhat higher water absorption (9.7%) at the specified temperature, which is presumably related to a low content of the plastifying component (kaolin), the absence of quartz sand and, possibly, an excessive quantity of the feldspar material. Mixture 1 has high water absorption (16.44%) even at the final firing temperature, which is determined by its low sinterability despite the

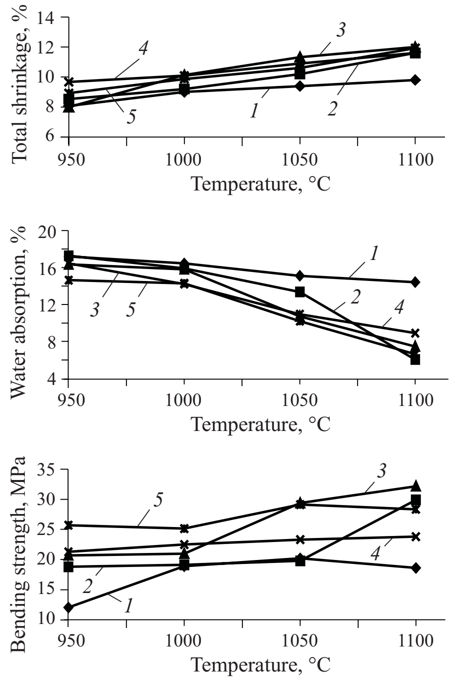

Fig. 1. Dependence of variation in total shrinkage, water absorption, and bending strength of tiles on their firing temperature. Curve numbers correspond to mixture numbers.

TABLE 2

Raw material	Weight content, %, in mixture				
	1	2	3	4	5
Clay from Nikol'skii Works	42	39	45	55	63
Prosyanovskoe kaolin	14	18	16	5	16
Quartz sand	19	8	9	–	17
Feldspar material	20	35	30	40	–
Lime	5	–	–	–	6

presence of lime. A comparison of mixture 1 with the industrial mixture shows that good sinterability with a high content of quartz sand is provided by a high content of plastifying components (clay and kaolin); a feldspar additive in the amount of 20% does not ensure the required sintering.

The strength parameters correlate with water absorption data: the sintering of mixtures at the final firing temperature ensures high strength of the mixtures developed. The maximum strength compared with industrial mixture 5 (28.35 MPa) is registered in mixtures 2 (29.91 MPa) and 3 (32.16 MPa) with 30 – 35% feldspar component and 8 – 9% quartz sand. An increase in the content of the feldspar material to 40% in quartz-free mixture 4 leads to a certain decrease in strength (23.8 MPa).

Mixtures with 30 – 40% feldspar additive meet the requirements of GOST 6141–91 regarding water absorption and strength.

The use of quartz-feldspar waste makes it possible to eliminate lime from the mixture composition and decrease the amount of quartz sand requiring milling.